[0021] In an embodiment, the summing amplifier is configured to transmit the trip signal to a relay configured to cut off the current in response to the trip signal.

[0022] According to some exemplary embodiments of the invention, there is provided a system including: a load; a power source configured to supply power to the load; a switch coupled between the power source and the load; and a protection circuit configured to sense a load current passing through the load and to generate a trip signal indicative of an overcurrent condition, the protection circuit including: a first current integrator and a second current integrator, each of the first and second integrators being configured to integrate an input voltage proportional to the load current; a summing amplifier configured to receive an offset voltage, to amplify a signal from the second integrator, and to generate a dynamic trip threshold based on the input voltage and the offset voltage; and a comparator configured to compare an output of the first current integrator and the dynamic trip threshold, and to generate a trip signal at a trip time when the dynamic trip threshold is equal to an output of the first integrator, the trip signal indicating an overcurrent condition, and wherein the switch is configured to actuate in response to receiving the trip signal, and to stop current flow from the power source to the load.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] The above and other features and aspects of the invention will become more apparent by the following detailed description of exemplary embodiments thereof with reference to the attached drawings, in which:

[0024] FIG. **1** is a diagram illustrating an ideal I^2t trip characteristic of an electronic protection device;

[0025] FIG. **2** is a block diagram illustrating a system utilizing a protection circuit according to some exemplary embodiments of the invention;

[0026] FIG. **3** is a block diagram illustrating a protection circuit according to some exemplary embodiments of the invention;

[0027] FIG. **4** is a circuit diagram illustrating the protection circuit of FIG. **3** according to some exemplary embodiments of the invention; and

[0028] FIG. **5** is a diagram comparing the ideal I^2t trip characteristic with that of the approximated I2t trip characteristic of the protection circuit according to some exemplary embodiments of the invention.

DETAILED DESCRIPTION

[0029] The attached drawings for illustrating exemplary embodiments of the invention are referred to in order to gain a sufficient understanding of the invention, the merits thereof, and the objectives accomplished by the implementation of the invention. The invention may, however, be embodied in many different forms and should not be construed as being limited to the exemplary embodiments set forth herein; rather, these exemplary embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the concept of the invention to those skilled in the art.

[0030] Hereinafter, the invention will be described in detail by explaining exemplary embodiments of the invention with reference to the attached drawings. In the drawings, like reference numerals are used throughout the figures to reference like features and components.

[0031] FIG. **2** is a block diagram illustrating a system **100** utilizing a protection circuit **110** according to some exemplary embodiments of the invention.

[0032] Referring to FIG. **2**, the system **100** may include a power source **102**, a load **104** powered by the power source **102** though a conductor (e.g., a wire) **106**, a switch (e.g., relay) **108** for switchably connecting the power source **102** and the load **104** (i.e., the switch **108** is located in a current path between the power source **102** and the load **104**), and a protection circuit **110** for monitoring the current I passing through the conductor **106** and controlling the operation (e.g., activation and deactivation) of the switch **108** based on the monitored current I.

[0033] According to some embodiments, the protection circuit **110** maintains the switch **108** in an activated state (e.g., a closed or turned ON state) when the conductor current I is at a level that does not exceed the thermal capacity of the conductor **106**, and deactivates (e.g., opens, turns OFF, or "trips") the switch **108** when the thermal capacity of the conductor **106** is reached or exceeded. The trip characteristic of the protection circuit **110** may be substantially similar to that shown in FIG. **1**, where the protection circuit **110** ensures that the current-supplying operation of the system **100** is confined to region A (e.g., the area below the curve **10**) in FIG. **1** and does not reach region B (e.g., the area above the curve **10**) in FIG. **1**. For example, the protection circuit **110** deactivates the switch **108** within about 100 millisecond of a current, which is 10 times higher than the conductor's rated current, passing through the conductor **106**. In some examples, deactivation may occur within about 4 seconds of passage of a current that is twice the rated current.

[0034] Thus, the protection circuit **110** isolates a fault in the system **100** (e.g., a short circuit in the load **104**) in a timely manner, by preventing an overcurrent condition that exceeds the thermal capacity of the conductor **106**.

[0035] The protection circuit **110** may sense (e.g., measure) the current I using a sense resistor, a hall effect sensor, and/or any other suitable means known to a person of ordinary skill in the art. The switch **108** may be an electromechanical relay, a solid state switch, or the like.

[0036] FIG. **3** is a block diagram illustrating a protection circuit **110** according to some exemplary embodiments of the invention.

[0037] In some embodiments, the protection circuit **110** may include a first current integrator **112**, a second current integrator **114**, a summing amplifier **116** and a comparator **118**. Each of the first and second current integrators **112** and **114** integrates an input voltage V_{Curr} that is proportional to the sensed current I. In some examples, the input voltage V_{Curr} represents a voltage output of a current sensor within the protection circuit **110** measuring the sensed current I. The summing amplifier **116** amplifies a signal from the second current integrator **114** to generate a trip threshold (e.g., a dynamic trip threshold) that is based on the input voltage V_{Curr} (which is proportional to the current I). The comparator **118** compares the output of the first current integrator **112** with the trip threshold, and generates a trip signal S_{Trip} when the comparative relationship between the output of the first current integrator **112** and the trip threshold has changed. For example, upon being tripped, the comparator **118** may output a voltage that is higher (or lower) than that outputted before being tripped.